

# Quench Analysis

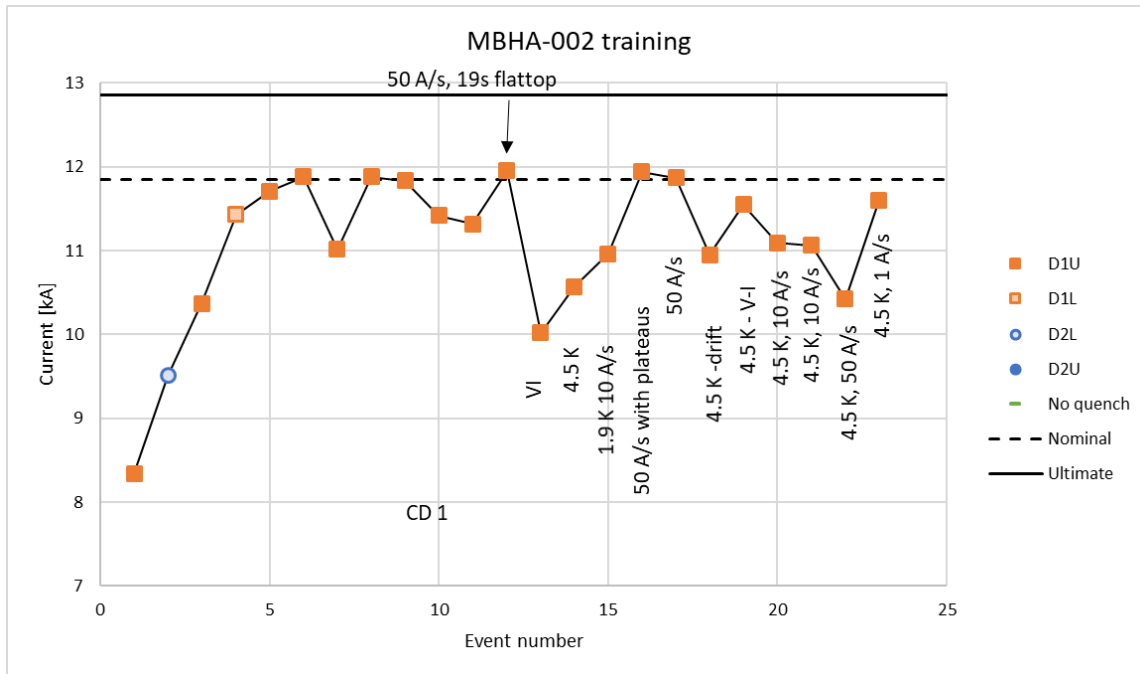
## MBHA-002

### Quick upate

### 04 Febuary 2020

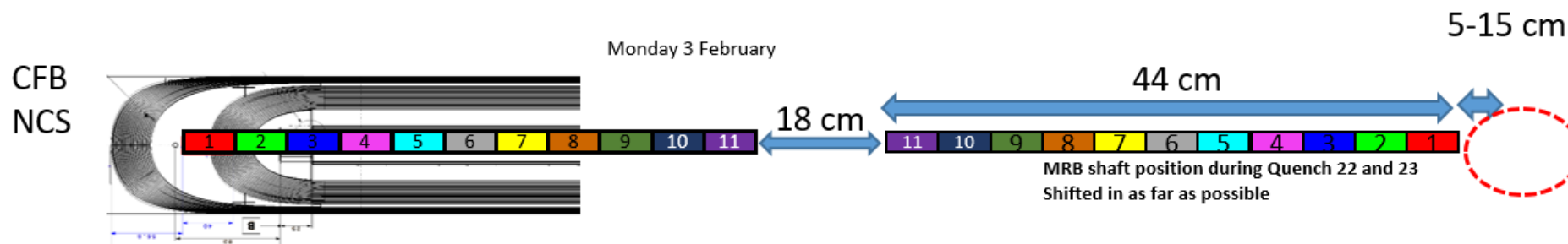
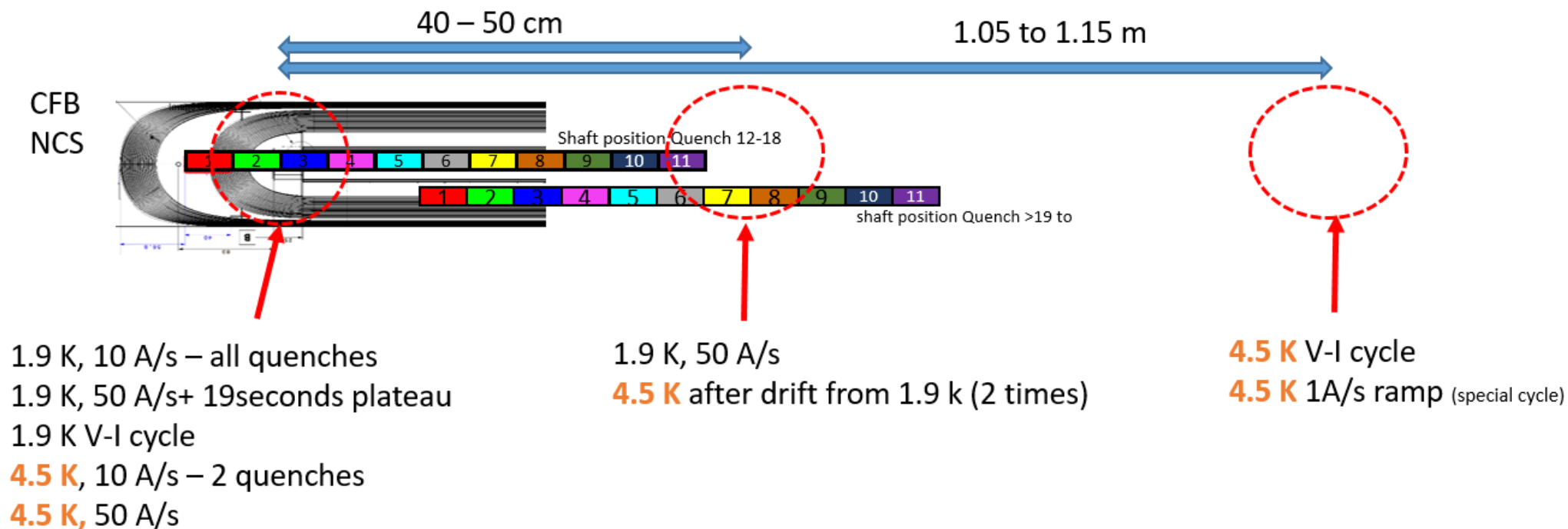
G. Willering, V. Desbiolles, G. Ninet, F. Mangiarotti  
L. Fiscarelli

# Quench history

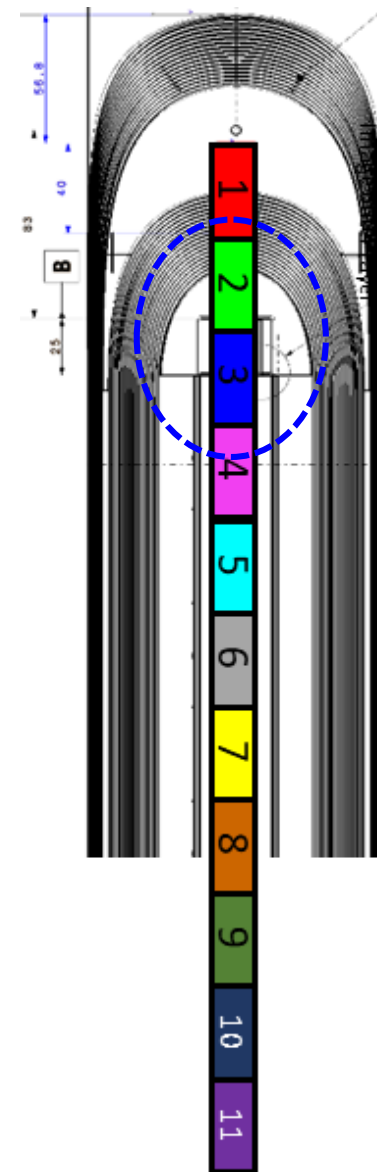
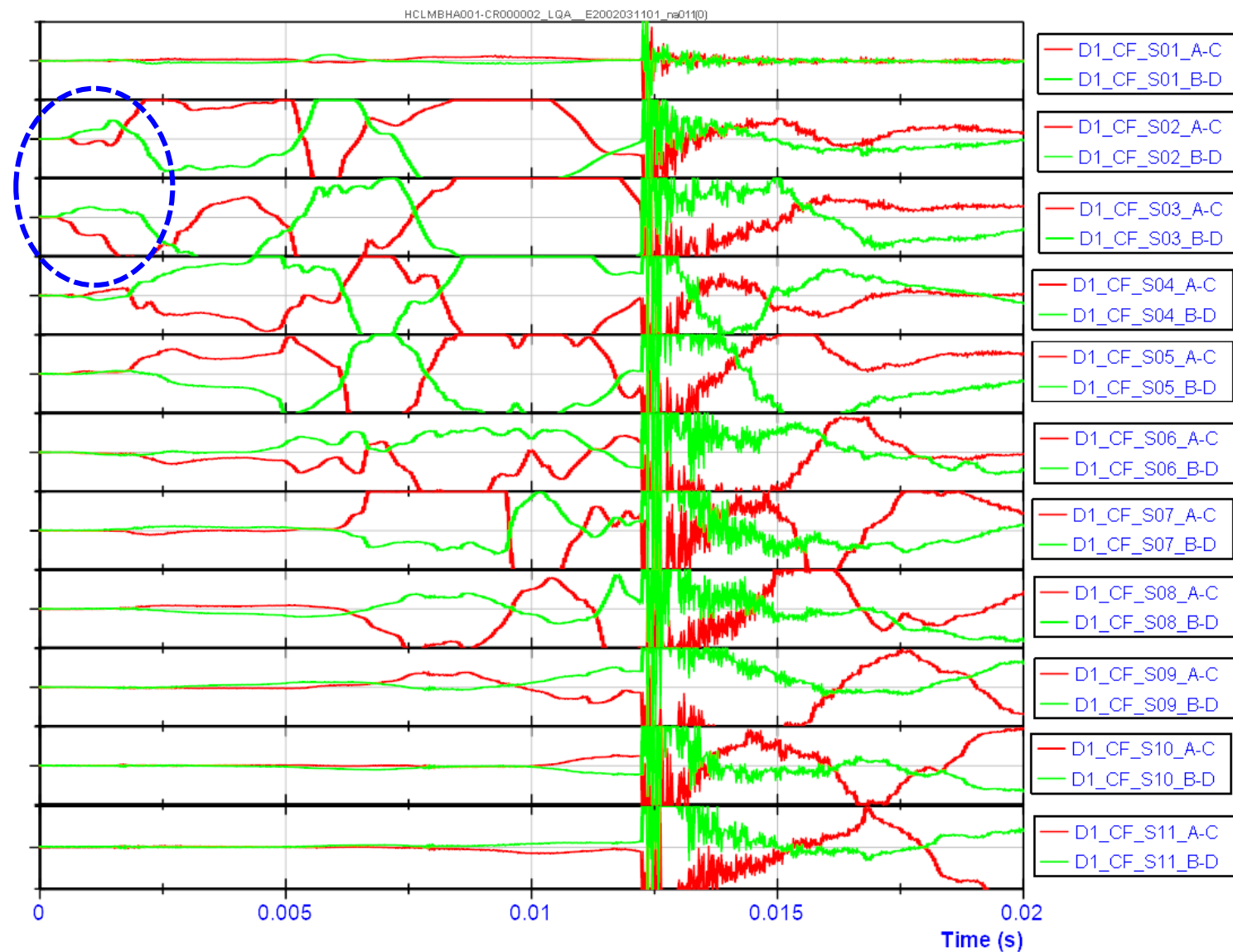


	Ramp rate	Temperature	Current	Precursor	Location	Location	QA	LQA
1	10	1.9	8.34	Yes	D1U	CS	head	1 and 2
2	10	1.9	9.51	Yes	D2L	CS	head	1
3	10	1.9	10.37	Yes	D1U	CS	head	1
4	10	1.9	11.43	Yes	D1L	CS	head	1
5	10	1.9	11.71	No	D1U	NCS		5
6	10	1.9	11.88	No	D1U	NCS		5
7	10	1.9	11.015	No	D1U	NCS		5
8	10	1.9	11.88	Yes	D1U	CS	head	1
9	10	1.9	11.83	No	D1U	NCS		5
10	10	1.9	11.42	No	D1U	NCS		5
11	10	1.9	11.32	No	D1U	NCS	head	<1 (shifted)
12	50	1.9	11.95	No	D1U	NCS	head	3
13	VI	1.9	10.02	No	D1U	NCS	head	3
14	10	4.5	10.57	No	D1U	Straight	~40-50 cm from head	>11
15	10	1.9	10.96	No	D1U	NCS	head	3
16	flattops	1.9	11.938	No	D1U	Straight	~40-50 cm from head	
17	50	1.9	11.87	No	D1U	NCS	head	<1
18	10	4.5	10.95	No	D1U	Straight	~40-50 cm from head	>11
19	V-I	4.5	11.55	No	D1U	Straight	~105 to 115 cm from head	>11 (shifted)
20	10	4.5	11.09	No	D1U	NCS	head	<1 (shifted)
21	10	4.5	11.06	No	D1U	NCS	head	<1 (shifted)
22	50	4.5	10.42	No	D1U	NCS	head	<1 (shifted)
23	1	4.5	11.6	No	D1U	Straight	~105 to 115 cm from head	>11
24	10	1.9	ongoing					

# Quench Location

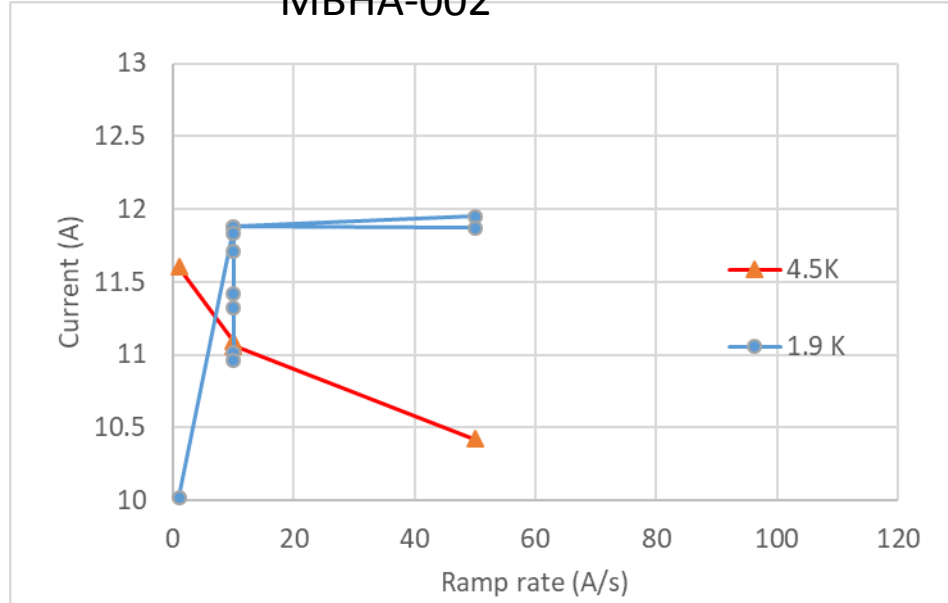


Quench 22: 10.43 kA @ 4.5 K, 50 A/s  
Abnormal propagation:

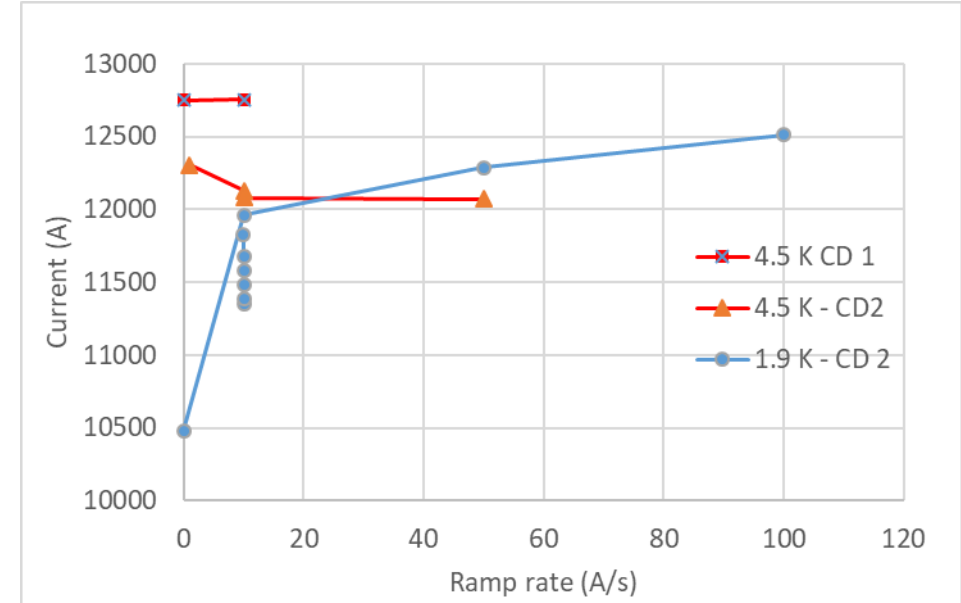


# Ramp rate and temperature dependency

MBHA-002



For comparison MBHB-001 hybrid



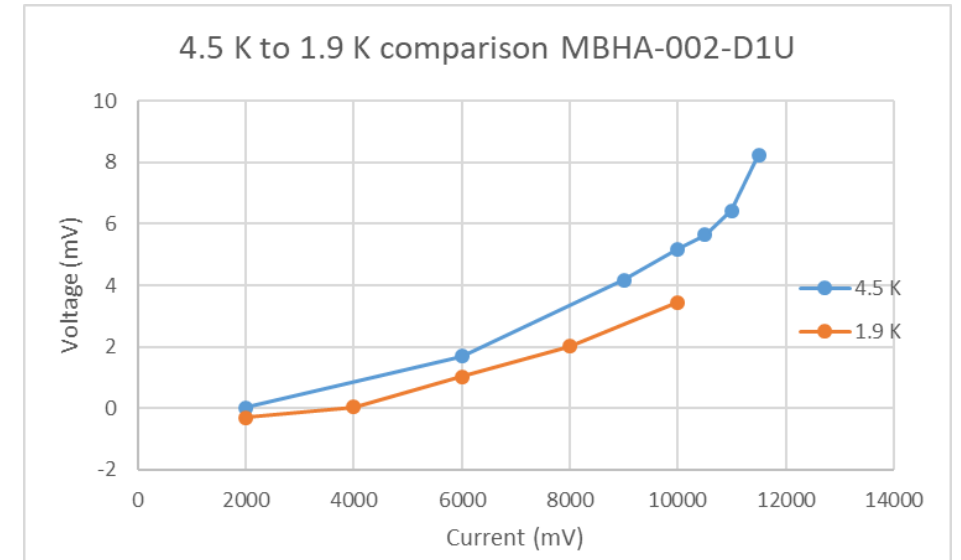
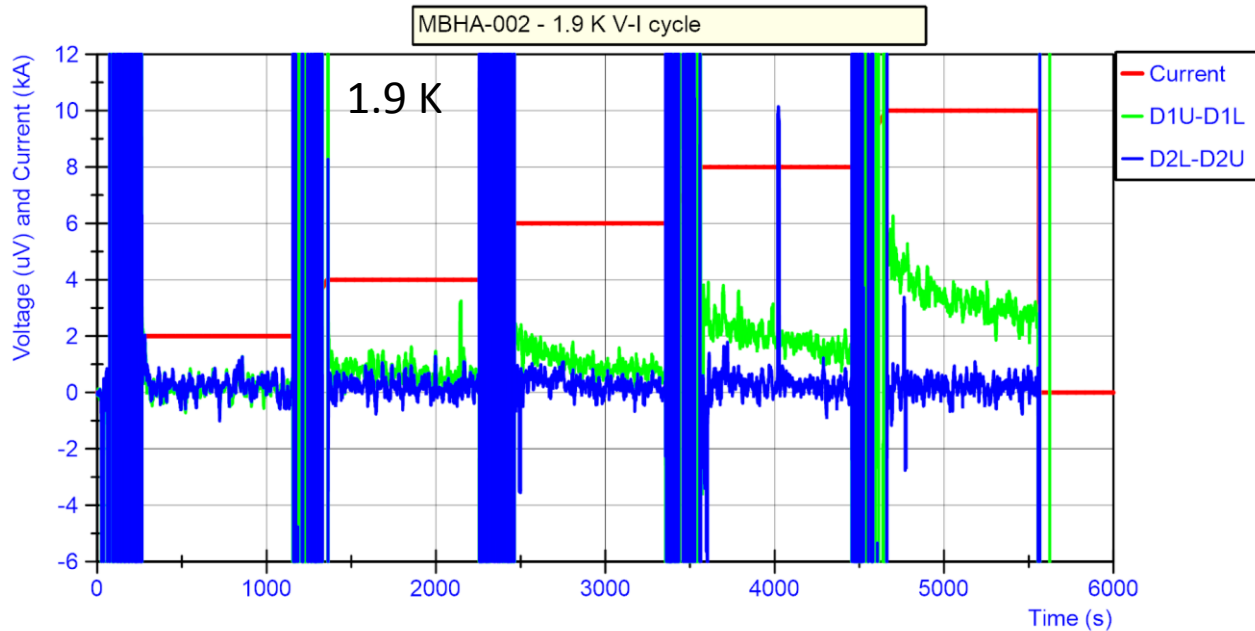
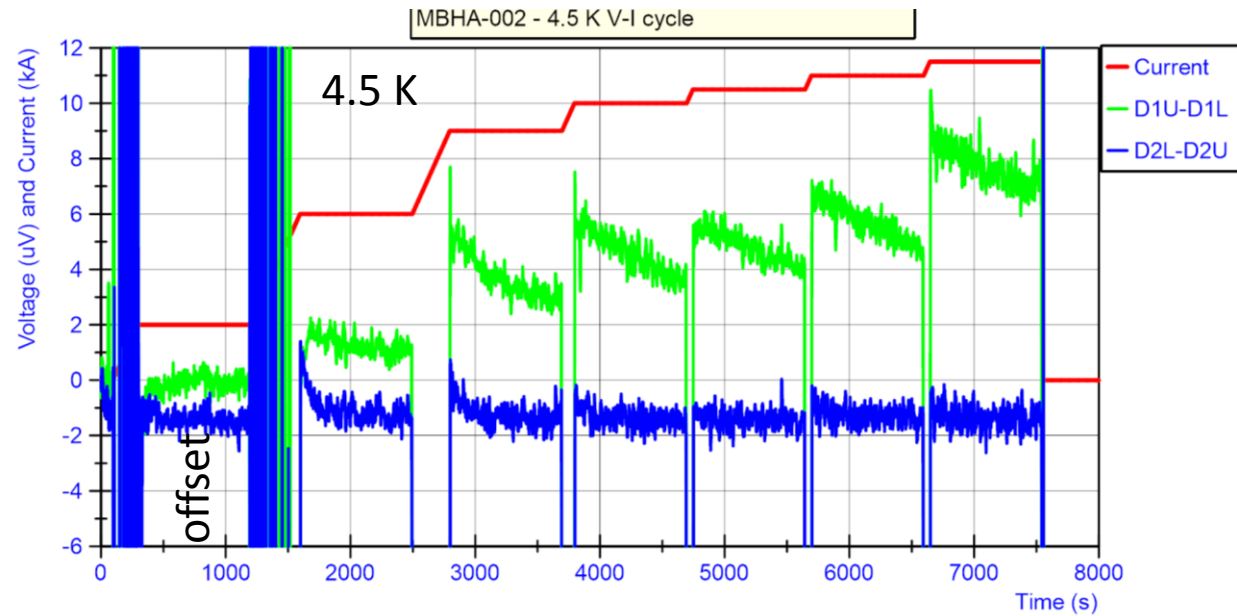
Instability at 1.9 K at 10 A/s.

Reproducibility at 4.5 K at 10 A/s.

4.5 K higher ramp prate gives lower quench current

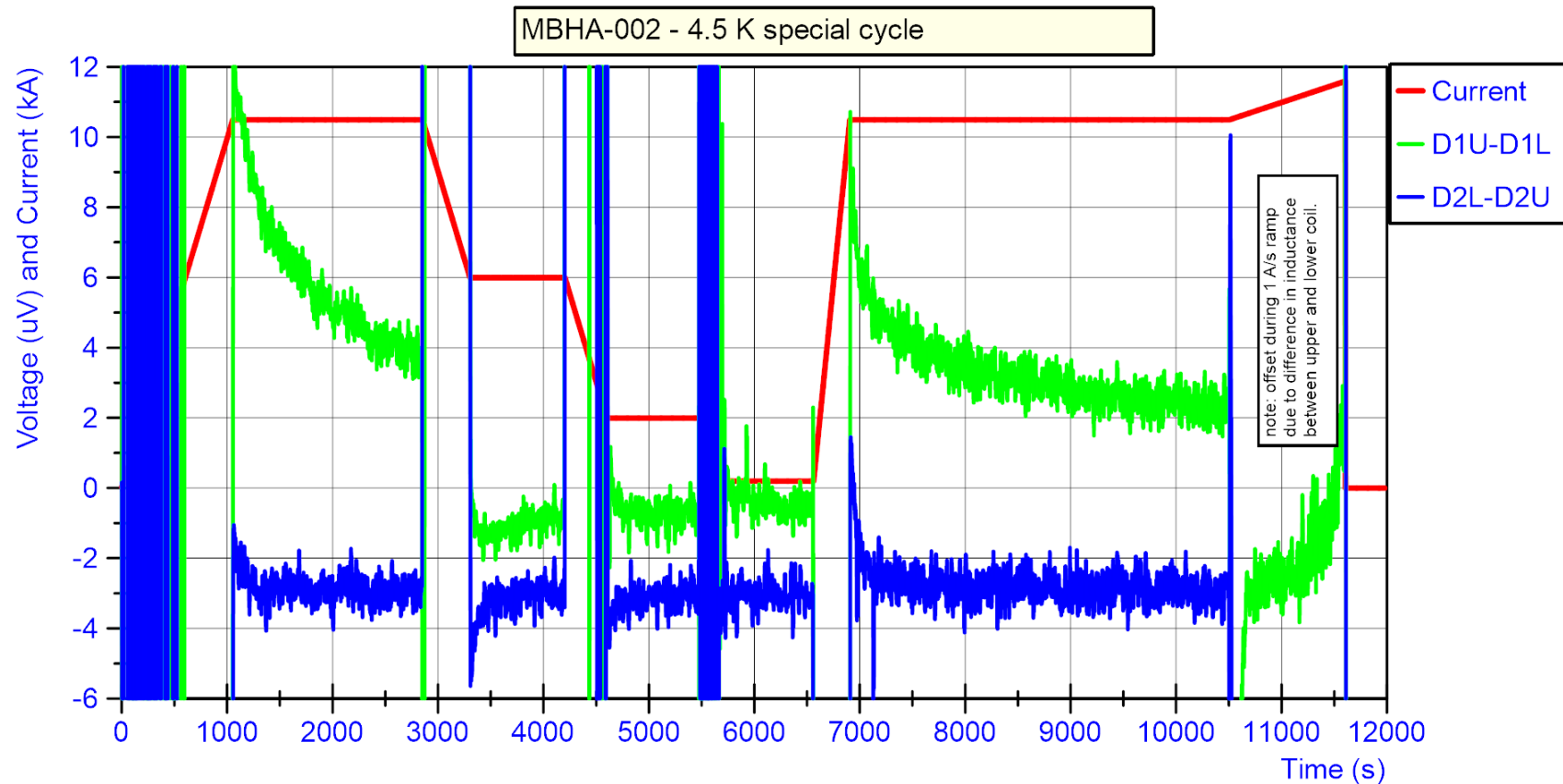
4.5 K highest quench current with very low ramp rates

# V-I measurements



- Significant voltage buildup in voltage in coil D1U
- Voltage buildup starts from very low current of 6 kA
- Clear decay of voltage on current plateaus.
- No sign of degradation in aperture 2, nor in coil D1L

# Additional V-I measurements

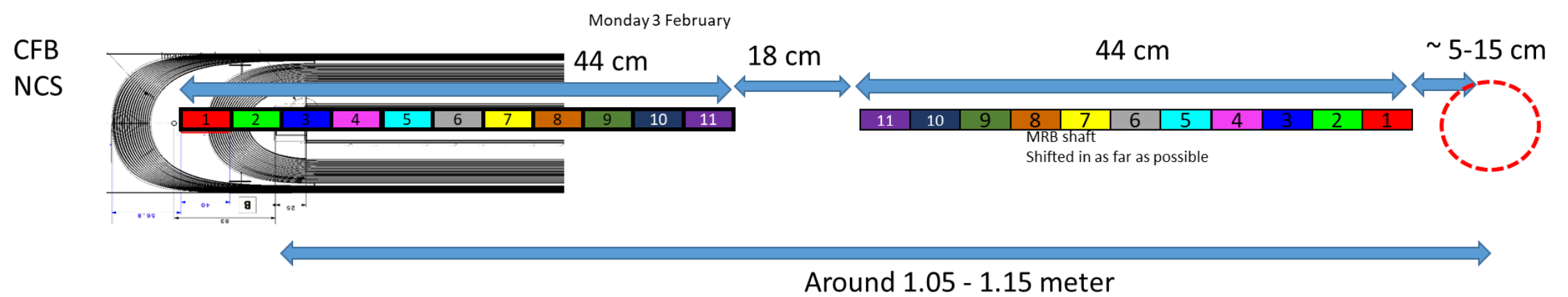
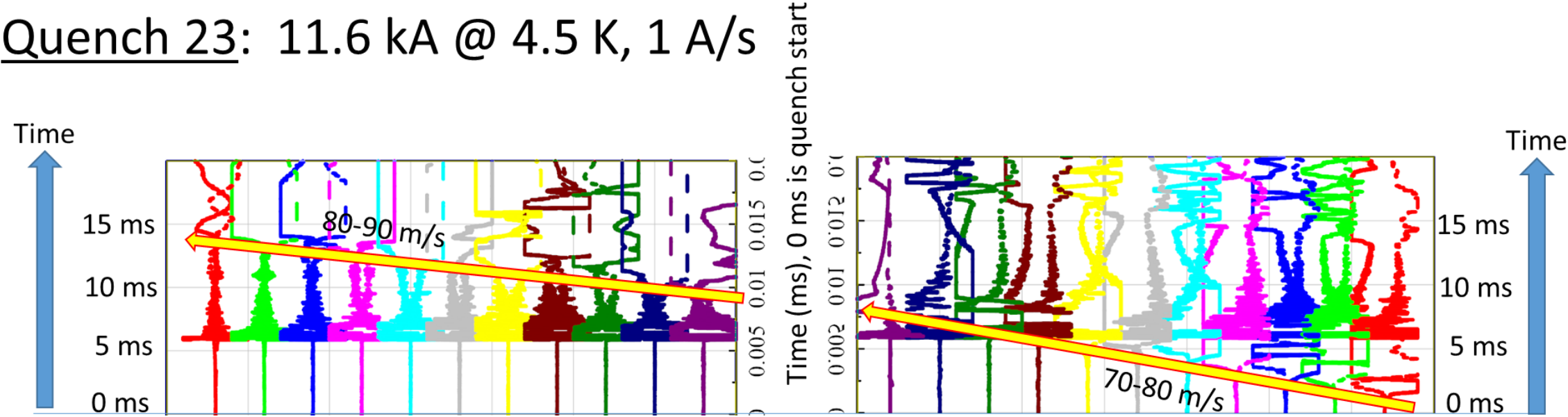


Several features:

- 10 A/s ramp straight to 10.5 kA, reaching 12 uV, showing decay time constant on 30 minutes plateau
- Ramp down to 6 kA, shows **negative voltage**
- 30 A/s ramp to 10.5 kA (lower voltage than 10 A/s ramp, this can be influenced by pre-cycles).

# Quench propagation

Quench 23: 11.6 kA @ 4.5 K, 1 A/s

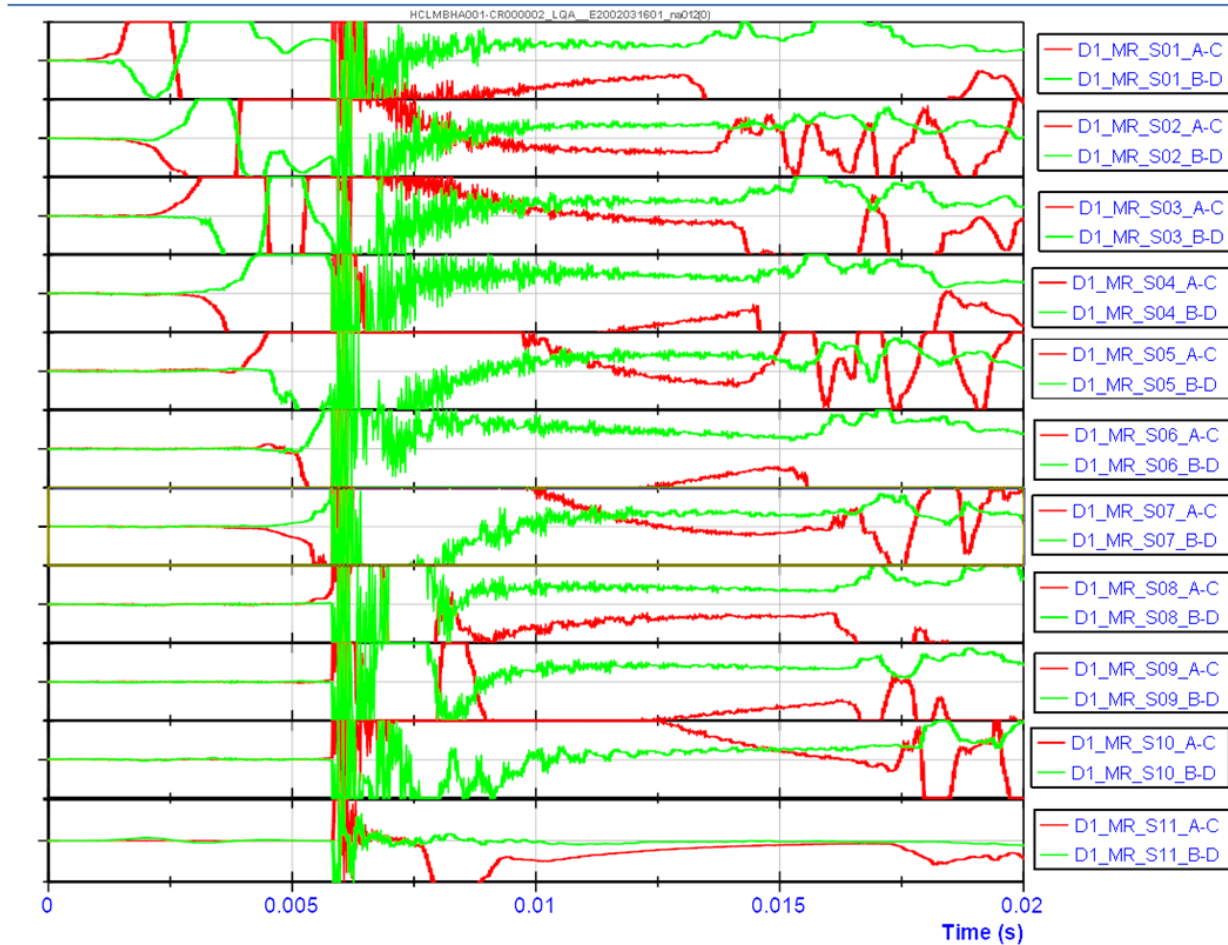
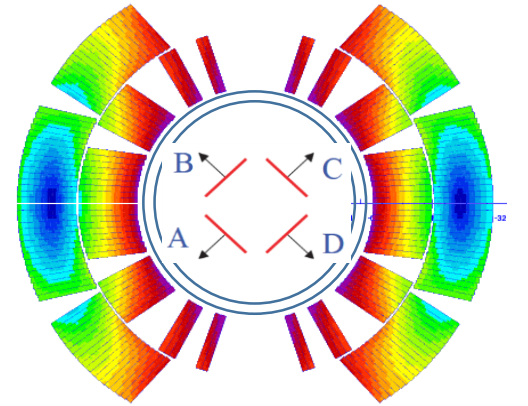


# Anomaly in LQA signals

Quench 23: 11.6 kA @ 4.5 K, 1 A/s (start 1.1 meter from the head, MRB shaft inserted towards CFB end)

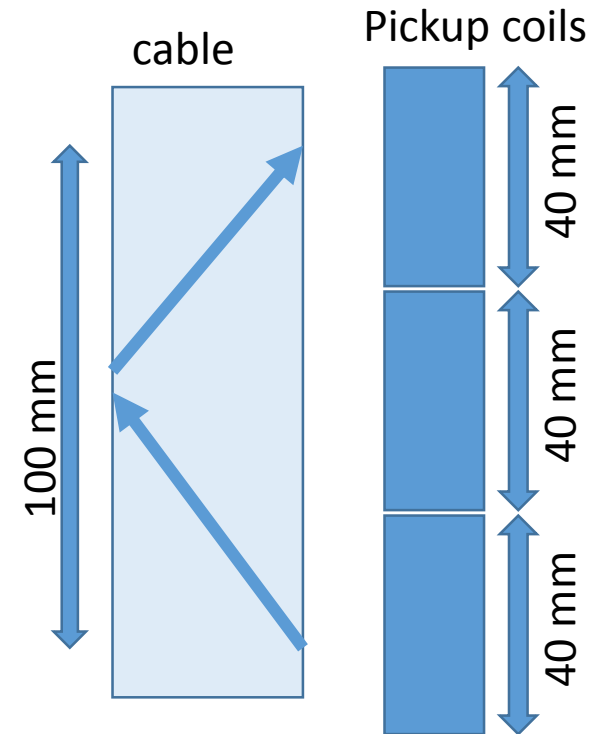
Abnormal propagation:

Curves A-C flip sign for most segments. (transposition pitch 100 mm, pickup coil length 40 mm)



To be studied:

Can a quench propagate through a single strand (or a few strands)

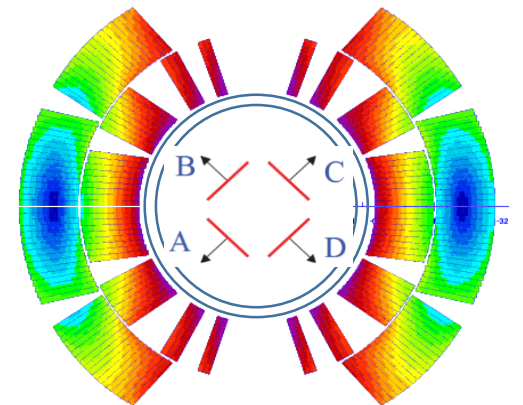


**To check**  
Quench signal should repeat each 5 segments.

If always the same strand has propagating quench, repeatedly between quench.

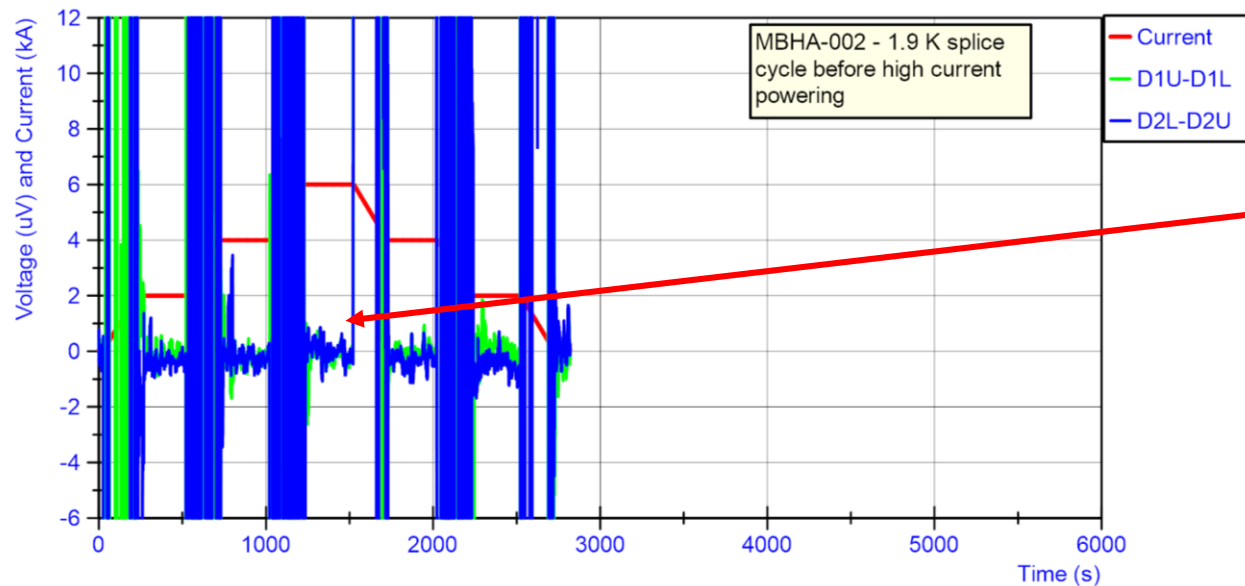
# Conclusion

- Coil D1U has a clear damage
  - Decay in V-I curves indicate current redistribution -> Local defect
  - Voltage buildup starts at very low current -> severe damage to some of the conductor
  - 3 quench locations:
    - We believe that the 50 A/s ramp at 4.5 K forces the current through the defect the most and may indicate the location of the defect. The defect is therefore most likely in the head.
    - At 1.9 K the large variation in quench current indicates self-field instabilities
    - Quenches in the straight segment are assumed to result from current redistribution effects caused by the defect.
  - The pickup coils give propagation signals on the straight part inconsistent with any earlier proposed model.
- There are no good models for localizing quenches in the head.  
Difficult to pinpoint the defect to a single turn.



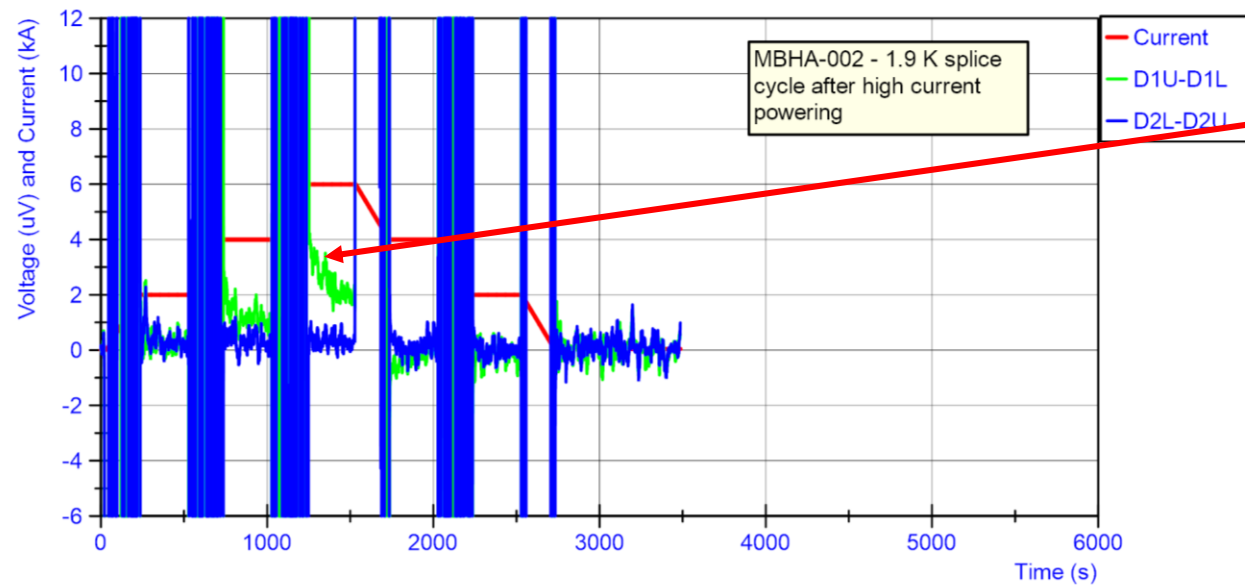
# Discussion on the cause

- Cool down damage? (the head non-connection side sees negligible thermal gradient  $\ll 30$  K)
- Due to high quench integral? **No**, the NCS head did not see a quench yet at the first suspicious quench.
- Due to powering? See next slide.
- Production damage?



First powering to 6 kA was a splice cycle including V-I measurements.  
No sign of any voltage.

This was the first time this magnet reached 6 kA.



Clear voltage at 6 kA  
This was the last powering before warm up.

Conclusion: a weakness appeared, or an existing weakness degraded more during the powering/quenching.

# Backup